Ferrofluid Bubble Exploding in Water

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Background

- Ferrofluids consist of nanoscale ferromagnetic particles suspended in oil, which allows for the fluid to be manipulated with magnetic fields (Liu, J., Lawrence, E. M., Wu, A., Ivey, M. L., Flores, G. A., Javier, K., 1995). Since it's discovery, many properties of the fluid have been observed and recorded. One interesting property of ferrofluids that was observed at the hydrodynamics lab is that when mixed with a specific amount of diluted indicator solution and injected into ionized water, the ferrofluid would form "bubbles" or globules with indicator suspended at the core.

- Therefore, the purpose of this research is to study the effect of the ferrofluid bubble on the dispersion of the indicator in tap water when sodium stearate as a surfactant and magnetic fields are individually used to release the indicator.

Results

- When the surfactant sodium stearate was used to release the indicator, the dispersion tended to be more uniform at first, then form a mushroom shape, and diffuse upwards.
- When the magnetic field was used to release the indicator, the trend observed was that the indicator dispersed in the direction of the magnet and opposite as well.

Figure I

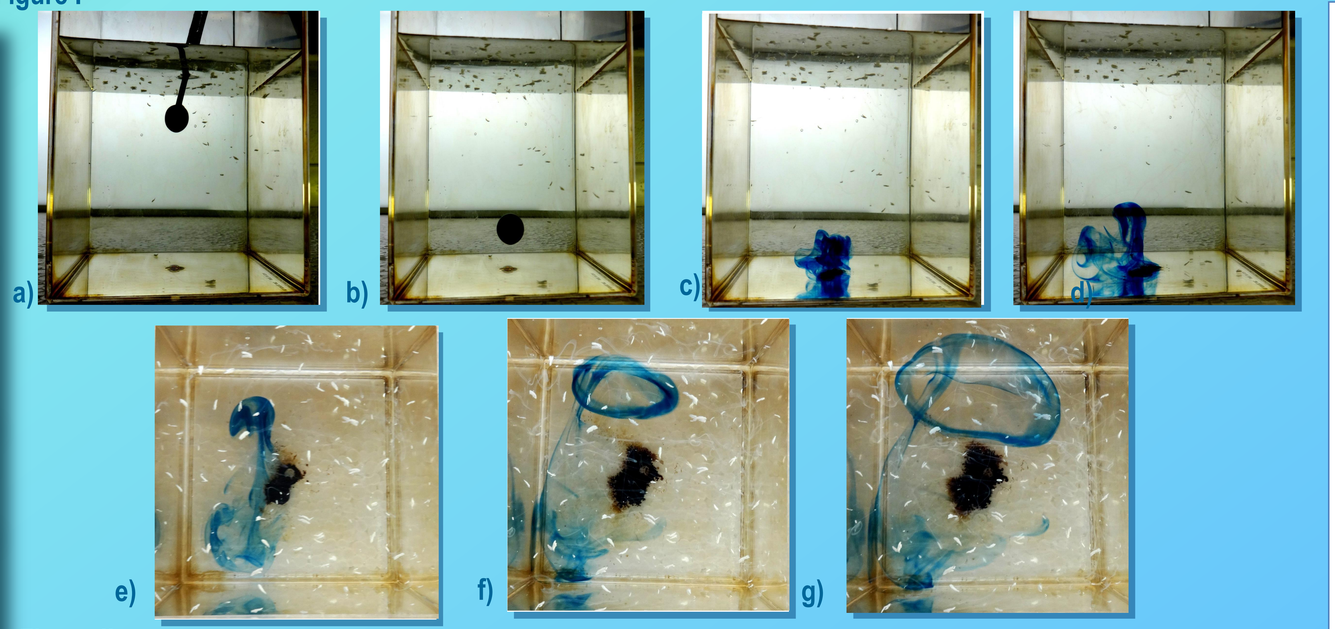

Figure II

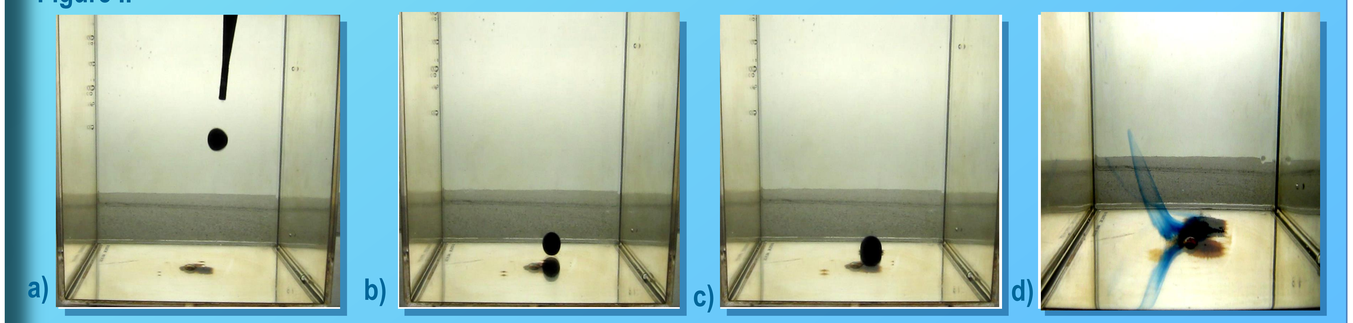

Figure I: Explosion with Suspended Sodium Stearate
a) Ferrofluid bubble is dropped in water with surfactant**. b)** Ferrofluid bubble is suspended in solution. **c)** When the bubble reaches the bottom of the container, the bubble explodes, releasing the chemical indicator. **d)** The chemical indicator diffuses through the water, leaving the heavy iron particles from the bubble behind**. e)** Seen in this top view of the explosion, the diffusing chemical indicator forms a rising globule of indicator. **f)** As the chemical indicator rises, a ringlet spiral of the indicator is formed. **g)** The indicator continues to rise until it surfaces on top of the water.

Figure II: Explosion with Magnetic Field
a) The ferrofluid bubble is dropped in the water without surfactant. **b)** Ferrofluid bubble is suspended in the ionized water as it drops to the bottom of the container**. c**) Once the ferrofluid bubble reaches the bottom, the magnet is placed underneath the container**.**
d) As a result of the magnetic field pulling the iron out of the bubble, the globule pops, releasing the chemical indicator inside and allowing it to diffuse throughout the water.

Discussion

- Sodium stearate is a chemical compound commonly found in soap. One property of sodium stearate is the ability to dissolve hydrophobic compounds such as oil. When this compound is dissolved into the tap water, it disperses throughout the entire container. As a result, the surfactant then reacts with the oil in the ferrofluid globule throughout the entire surface area to dissolve the oil and release the indicator. This is most likely what causes the indicator to disperse uniformly at first and diffuse upwards in the shape of a mushroom. On the other hand, when a magnetic field is used to release the indicator, part of the bubble is pulled apart due to the force of the field on the ferromagnetic particles. This causes the bubble to rupture and release the indicator. When the indicator is released, the impulse from the rupture causes it to disperse sideways opposite to the magnet, while at the same time the freed ferromagnetic particles travel towards the magnet causing a current to form and disperse the indicator toward the magnet.

References

- Liu, J., Lawrence, E. M., Wu, A., Ivey, M. L., Flores, G. A., Javier, K., et al. (1995). Field-Induced Structures In Ferrofluid Emulsions. Physical Review Letters, 74(14), 2828-2831.